Validation of the MadAnalysis 5 implementation of CMS-PAS-SUS-13-016

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June 24, 2014

The analysis CMS-PAS-SUS-13-016 searches for new physics in the multi-top final state. The primary target is gluino-pair production followed by $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$, *i.e.* the T1tttt topology in the CMS simplified-model nomenclature. The dataset used corresponds to a total integrated luminosity of $\mathcal{L} = 19.7\ \text{fb}^{-1}$ at $\sqrt{s} = 8$ TeV.

The selection criteria are: two isolated leptons of opposite sign, a large number of jets, at least 3 b-tagged jets, and large missing transverse energy ($E_T^{\text{miss}} > 180$ GeV). Moreover, $|\eta| < 1$ is required for the two leading jets. As there is only one SR and no significant excess was observed, the analysis results in a simple upper limit on the number of SUSY events. Concretely, a signal of ≥ 4 events is excluded at 95% CL.

CMS provided us LHE files corresponding to two benchmark points for the T1tttt simplified model, one with $(m_{\tilde{g}}, m_{\tilde{\chi}_1^0}) = (1150, 275)$ GeV, and one with $(m_{\tilde{g}}, m_{\tilde{\chi}_1^0}) = (1150, 525)$ GeV. These will be compared in the following to the results obtained in the PAS for $(m_{\tilde{g}}, m_{\tilde{\chi}_1^0}) = (1150, 300)$ GeV and $(m_{\tilde{g}}, m_{\tilde{\chi}_1^0}) = (1150, 500)$ GeV, *i.e.* benchmark points that differ from ours by 25 GeV in the LSP mass.

The following comments and remarks are pertinent to this analysis,

- The gluino production cross section used was from the official web page, `https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections8TeVgluglu` and corresponds to a cross section of 6.7 fb for a gluino mass of 1150 GeV at 8 TeV center of mass energy. Note that the uncertainty of the cross section as quoted in the web page is 30%.

- The number of events obtained from the LHE file after passing it through Pythia and Delphes were found to be 28277 for the first point and 29455 for the second point. The merging parameters used for this validation corresponds to the one obtained from the LHE files. The LHE files were thus passed through Pythia6.4 for parton showering and hadronization, with the correct merging parameters (given in the LHE files) taken into account. The detector simulation was then performed using the modified version of Delphes, with a modified b-tagging efficiency incorporated in the CMS card taken from arXiv:1311.4736.

Table 1: Summary of yields for the $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ model for two benchmark points with $m_{\tilde{g}} = 1150$ GeV, as compared to official CMS results given on `https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS13016`. The uncertainties given for the CMS event numbers are statistical only. Note that the official numbers are available only for $m_{\chi_1^0} = 300$ GeV and 500 GeV.

	$m_{\tilde{\chi}_1^0} = 275$ GeV		$m_{\tilde{\chi}_1^0} = 525$ GeV	
cut	CMS result	MA 5 result	CMS result	MA 5 result
$2\ell + \geq 2$jets	9.8 ± 0.2	9.0	9.5 ± 0.2	8.9
$+\ E_T^{\text{miss}} > 180$ GeV	7.5	7.3	6.6	6.4
$+\ n_j > 4$	6.2	6.5	5.4	5.7
$+\ n_b > 2$	2.6	3.1	2.3	2.6
$+\ \lvert\eta\rvert_{j1} < 1$	2.2	2.7	2.0	2.1
$+\ \lvert\eta\rvert_{j1} < 1$	1.9	2.3	1.6	1.7

- The following cut flow numbers were obtained as tabulated in Table 1, and was compared with Table 2 of the note, corresponding to a gluino mass of 1150 GeV and an LSP mass of 275 GeV and 525 GeV, normalized to 19.7 fb^{-1} integrated luminosity. The preselection criteria was set to at least two opposite sign leptons and $n_{jet} \geq 2$, as described in the note.

- The jet energy scale was set to 1.0. A discussion on the jet energy scale follows later.

- Since the benchmark points obtained from the CMS collaboration do not correspond exactly to the ones in the PAS, we expect some difference in acceptance efficiencies. In this analysis we treat it as systematic errors.

- A change of jet energy scale from 1.0 to 0.95 or below results in a better agreement of the n_{jet} distributions for the benchmark points. The observed discreapncy in the peak of the distribution reduces from about 30% to about 10-15 %. Adddlitionally there are effecrs like pile up, jet lepton separation which may affect the jet distribution. These cannot be simulated reliably in a fast simulation.

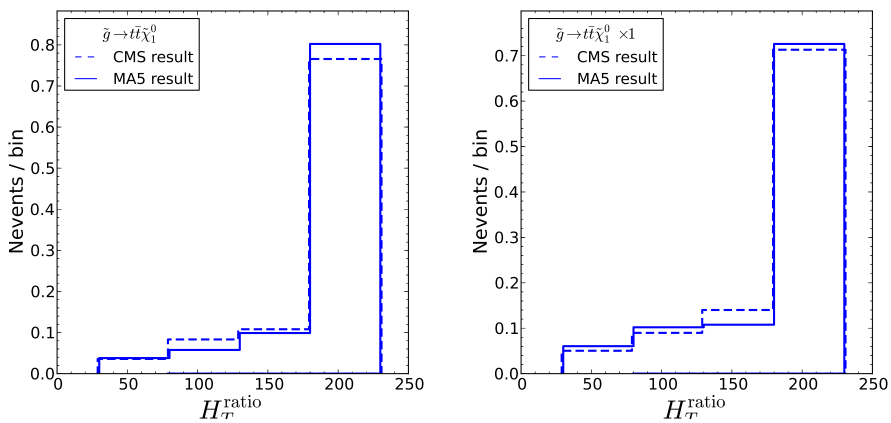

Figure 1: Distributions of the $H_T^{\rm ratio}$ on the left for $(m_{\tilde{g}},\, m_{\tilde{\chi}_1^0}) = (1150,\, 275)$ GeV, on the rigth for $(m_{\tilde{g}},\, m_{\tilde{\chi}_1^0}) = (1150,\, 525)$ GeV. The dashed lines correspond to the official CMS results in CMS-PAS-SUS-13-016, while the solid lines are obtained from our MadAnalysis 5 implementation. Note that the plots are made by applying all cuts excepting the one plotted.

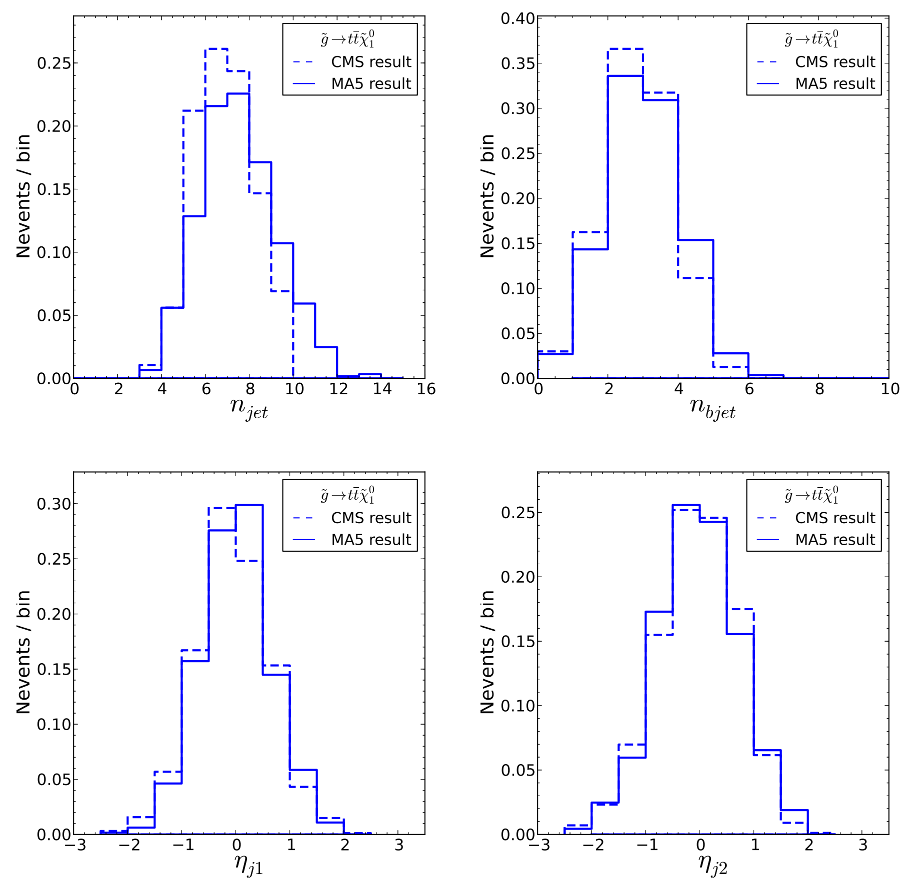

Figure 2: Distributions of the number of jets n_{jet} (top left), number of b-tagged jets n_{bjet} (top right), pseudo-rapidity of the leading jet η_{j1} (bottom left) and pseudo-rapidity of the sub-leading jet η_{j2}, for the benchmark point $(m_{\tilde{g}},\, m_{\tilde{\chi}_1^0}) = (1150,\, 275)$ GeV. The dashed lines correspond to the official CMS results in CMS-PAS-SUS-13-016, while the solid lines are obtained from our MadAnalysis 5 implementation. Note that the plots are made by applying all cuts excepting the one plotted.

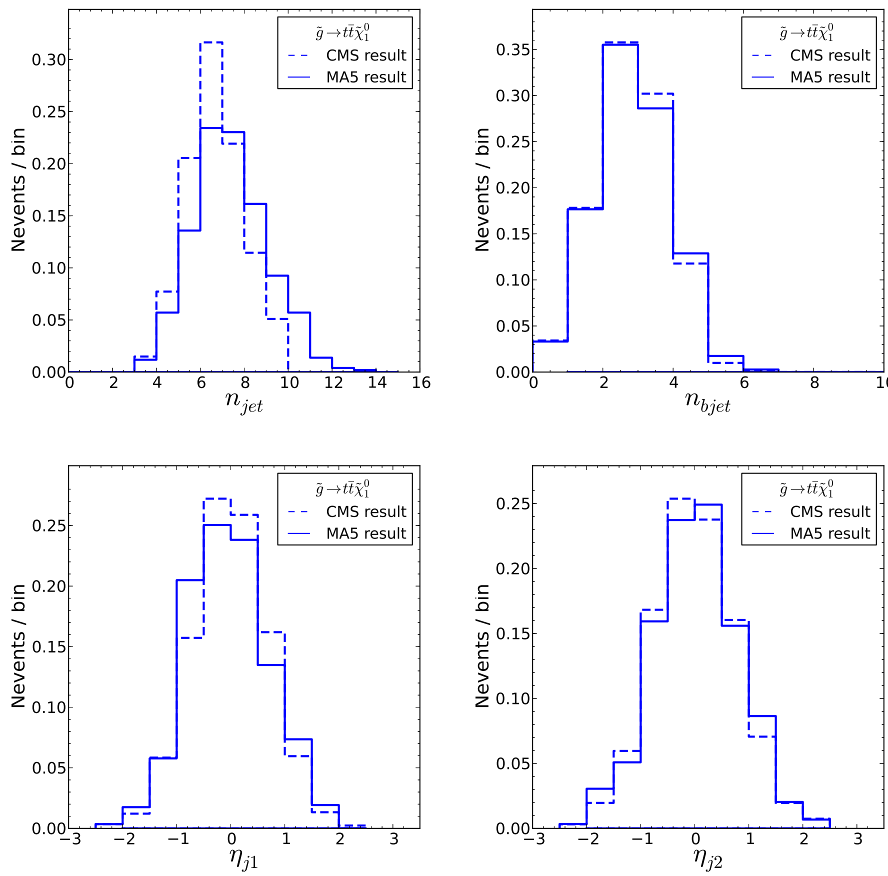

Figure 3: As Fig. 2 but for the benchmark point $(m_{\tilde{g}},\, m_{\tilde{\chi}_1^0}) = (1150,\, 525)$ GeV.